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(54) Anti-fouling Coatings

(57) An anti-fouling coating material for application to elastomer coated articles comprises a sheet of antifouling material 10 having a plurality of elongate slots 12 formed therein. The slots are arranged in columns, and are dimensioned and arranged to permit the material to deform so as to accommodate thermal expansion and contraction of the elastomer material, particularly in the process of curing of the elastomer coating after application of the material thereto. The coating material may include an elastomer layer 28 on the side thereof which is to be applied to the elastomer coated article. The slots 12 are preferably arranged in vertically staggered columns, with V-shaped, interleaving ends. The material may be formed as an elongate strip for application to a tubular structure 34 by helical wrapping, with the slots extending across the width of the strip.

Fig.3

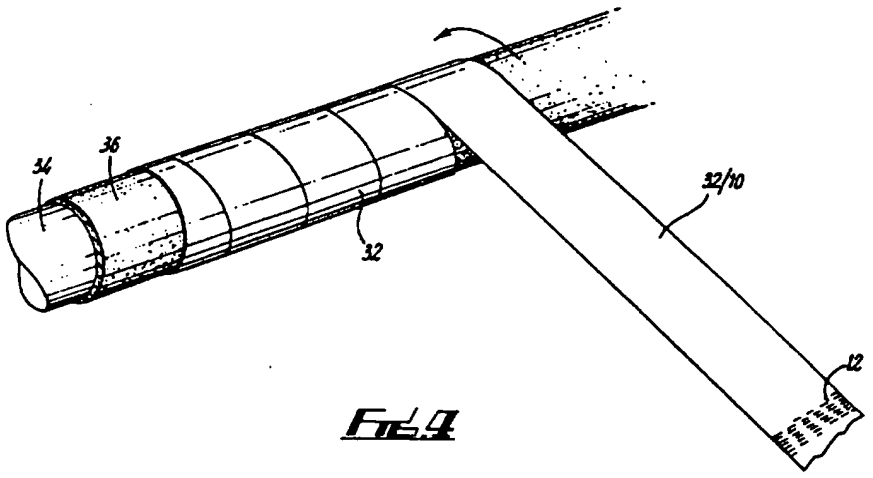

Fig.4

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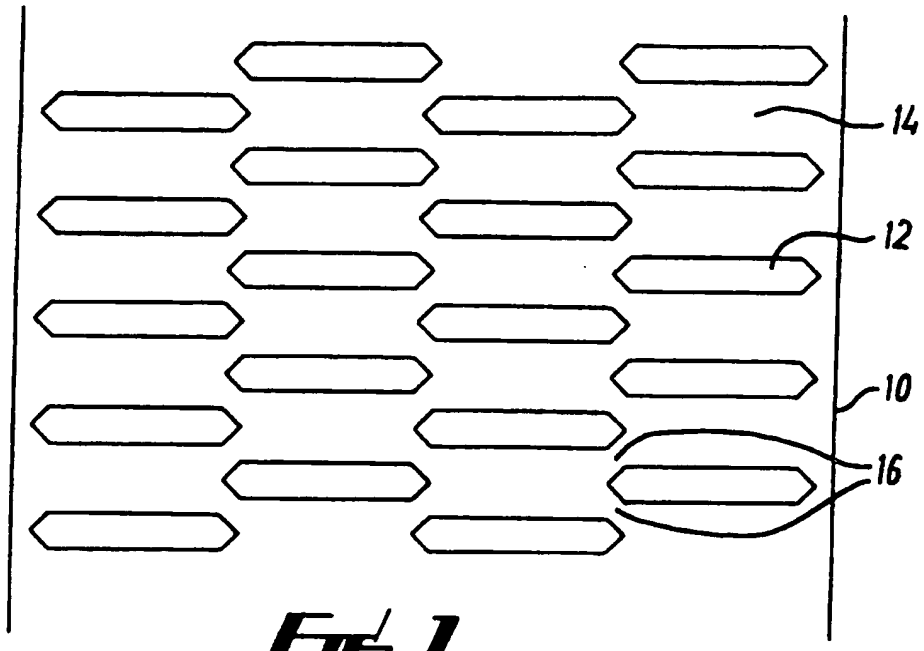

FIG. 1

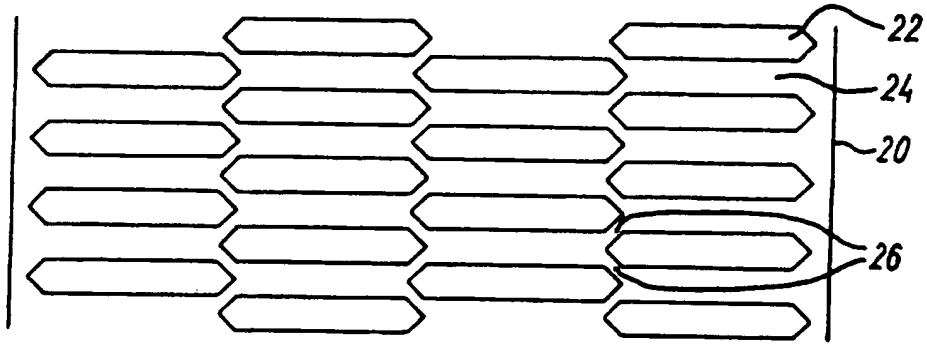

FIG. 2

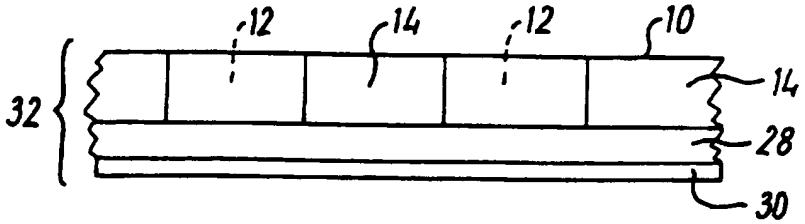

FIG. 3

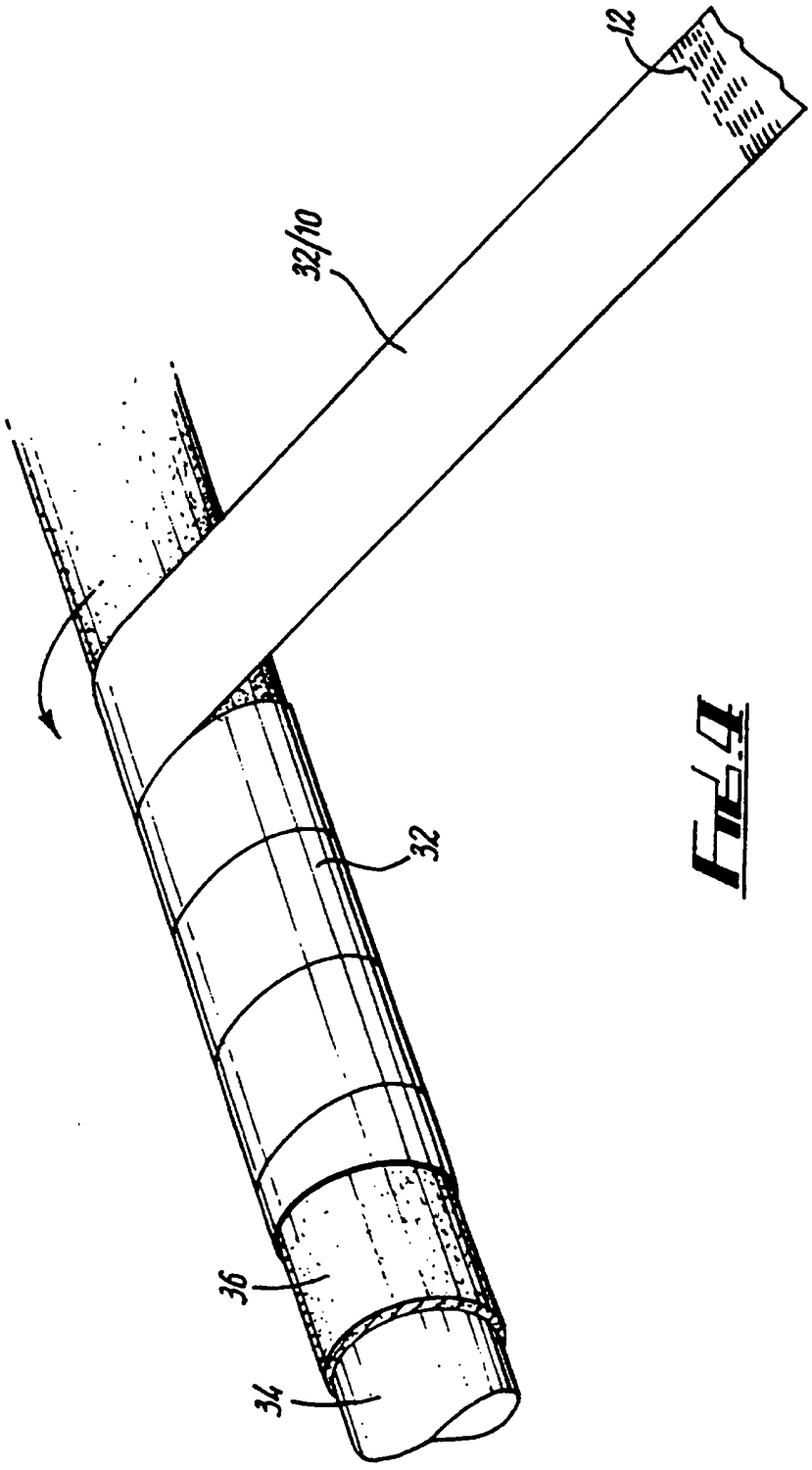

FIG. 4

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"Improvements in or Relating to Anti-Fouling Coatings"

This invention relates generally to coatings or coverings for protecting subsea structures, (particularly but not exclusively tubular structures such as risers, conductors and caissons) from fouling by marine organisms, and to processes for applying the coating or covering.

Marine fouling of offshore structures and their appurtenances by marine organisms, especially mussels, is extremely troublesome and incurs high costs. The major growth of mussels occurs from L.A.T. down to minus 100 ft. Growth rates vary dependent upon water temperature, tides and prevailing weather conditions. In ideal conditions mussel build up can be as high as 200 mm in a growing season.

Offshore operators require to increase the amount of steel required to construct an offshore structure to compensate for the additional weight (many tons) of accumulated marine organisms, but more importantly to compensate for additional wave loadings due to the increased dimensions of affected members.

It has been a known fact for many years that copper, or copper nickel with a high percentage of copper, emits copper ions when in a submerged condition, which in turn prevents adherence of marine life to the copper surface.

Copper or copper nickel sheet must not be allowed to come into contact with the steel it is protecting, otherwise a galvanic action occurs accelerating corrosion and also making the copper ineffective as an anti-fouling material (a switching off effect).

Many of the appurtenances of offshore structures as well as some of the main structures are normally protected from corrosion by elastomer coatings vulcanised and bonded to the steel surfaces. The elastomer coatings are normally factory applied to steel members before the platform is constructed. The elastomer coating provides an ideal electrical insulation between the steel and the anti-fouling material.

Many attempts in the past have been made to provide a technically acceptable and cost effective method of applying copper or copper nickel to tubular steel. Systems which have been used in the past are:-

a) Forming two half shells of copper nickel which are prepared and applied to the uncured elastomer coat and bonded in position.

b) Supporting copper nickel wire mesh or copper nickel granules in a matrix of elastomer or epoxy which is then applied in sheet form to the anti-corrosion coat on the tubular member.

c) Producing the copper nickel sheet in strip form approximately 150 mm wide in which a corrugation effect or a regular depression has been formed, which is then prepared and helically wrapped around the elastomer coat.

The coated pipe is placed into a steam autoclave where the temperature crosslinks the elastomer and forms a bond between the elastomer and steel and between the elastomer and copper nickel.

System a) is very labour intensive as only short lengths of half shells can be applied at one time and require precise positioning to leave the longitudinal gaps between the half shells necessary to accommodate differential thermal expansion between the shells and the elastomers.

System b) is not cost effective as major manufacturing costs are involved in producing the wire mesh or granules in a rubber or epoxy matrix. A further disadvantage is that only approximately 35% of the surface area has an exposure of copper nickel.

System c) provides an effective anti-fouling coating but requires a substantial thickness of elastomer beneath the corrugation or concave deformation of the copper nickel to prevent the copper nickel contacting the steel. Any variance from a smooth cylindrical form increases the C.D. (drag coefficient), lift and vortex shedding of the tubular member, and increases the forces generated by water velocity.

It has been generally accepted that it is not possible to successfully apply copper nickel sheet in strip form

and in a helical wrap fashion due to the substantial variation in expansion and contraction between copper nickel and elastomer. During the vulcanisation process the elastomer goes into a flow condition before crosslinking. On cooling down after vulcanisation the elastomer coating contracts to approximately 80% of its original applied thickness. High forces are exerted between the elastomers and copper nickel resulting in either a break in the bond or a buckling effect of the copper nickel cladding.

System c) as previously described overcomes this problem due to the bellows effect of the deformations in the copper nickel allowing to some degree the copper nickel to contract mechanically from its original circumference, but with the stated disadvantages.

International Patent Publication No. WO 93/14970 describes methods and materials whereby an anti-fouling coating may be applied as a wound strip of sheet material. The strip is formed from a series of panels, the adjacent edges of the panels being spaced from one another to accommodate expansion and contraction of the elastomer coating on top of which the strip is wound. The panels of the strip are connected together at the required spacing by means of strips of material secured to the panels by means of adhesives, the connector strips being removed after the panels have been secured to the elastomer coating. However, difficulties have been encountered in obtaining consistent results with the cupro-nickel adhesive.

It is an object of the present invention to provide improved materials and methods for applying metallic anti-fouling coatings to structures, particularly

tubular structures, which obviate or mitigate the abovementioned disadvantages of previous coating systems.

In accordance with a first aspect of the invention there is provided a metallic, anti-fouling, coating material adapted to be applied to an elastomer-coated article to be protected, said material comprising a generally planar sheet of anti-fouling material having a plurality of elongate slots formed therein.

Preferably, said slots are arranged substantially parallel to one another and are arranged in columns. Most preferably, adjacent columns are vertically staggered relative to one another. The slots are dimensioned and arranged such that the material can deform so as to expand and contract in at least one direction to accommodate thermal expansion and contraction of an underlying elastomer coating to which the material is secured, in use. The dimensions and arrangement of the slots are thus determined by the differential thermal expansion and contraction characteristics of the anti-fouling material and the elastomer coating.

Preferably also, said slots have six sides, having generally V-shaped ends. Most preferably, the slots are arranged in vertically staggered columns, the V-shaped ends of the slots of one column being interleaved with the V-shaped ends of the slots of adjacent columns.

Most preferably, the material comprises an elongate strip adapted to be helically wrapped about the length of a tubular article. The elongate slots preferably extend across the width of the strip, allowing the

strip to deform longitudinally with expansion and contraction of the underlying elastomer coating.

Preferably, the slots occupy 50% or less of the total surface area of the material. Preferably, also, the slots occupy at least 25% of the total surface area of the material.

Preferably, the sheet of anti-fouling material has a thickness in the range 0.5 mm to 2 mm.

In certain embodiments, the sheet of anti-fouling material may have a layer of elastomer material applied to one surface of said sheet. Preferably, such elastomer material has a thickness less than or equal to that of the sheet of anti-fouling material, most preferably in the range 0.5 mm to 1 mm.

Preferably, the length of the slots is in the range 3 mm to 50 mm. Preferably also, the width of the slots is in the range 1 mm to 6 mm.

In accordance with a second aspect of the invention, there is provided a structure having an elastomer coating applied to the surface thereof and a metallic anti-fouling coating in accordance with the first aspect of the invention applied to the surface of the anti-corrosion coating.

Preferably, said structure is a tubular structure and said anti-fouling material is in the form of an elongate strip helically wrapped about and along the tubular structure.

In accordance with still a further aspect of the

invention, a method of forming a structure in accordance with the second aspect of the invention comprises the steps of applying an elastomer coating to said structure, applying anti-fouling material in accordance with the first aspect of the invention to said tubular member on top of said elastomer coating so as to cover substantially all of the coated surface of the structure, and processing the resulting assembly to cure said elastomer coating and/or the elastomer layer of said anti-fouling material (if present) so as to bond said anti-fouling material to said coating.

It is preferred either that the elastomer coating is uncured or at least partially cured prior to application of the anti-fouling material to the structure. Where used, it is preferred that said elastomer layer is uncured or partially cured prior to the application of the anti-fouling material to the structure.

Preferably, a pressure strip is wrapped on top of the anti-fouling material prior to final curing of the assembly. Where the elastomer layer is omitted, a strip of material, such as nylon, is wrapped on top of the anti-fouling coating prior to the application of said pressure strip, so as to inhibit extrusion of elastomer through the slots in the anti-fouling material.

Preferably, the structure is a tubular structure and said anti-fouling material is an elongate strip applied to the structure by helically winding said strip about and along the tubular structure.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying

drawings in which:-

Fig. 1 is a plan view of a first example of slotted cupro-nickel anti-fouling material in accordance with the present invention;
Fig. 2 is a plan view of a second example of slotted cupro-nickel anti-fouling material in accordance with the present invention;
Fig. 3 is a side view of anti-fouling material including a layer of cupro-nickel material as shown in Fig. 1 or Fig. 2, a layer of elastomer and a release sheet; and
Fig. 4 is a perspective view of an elastomer-coated subsea tubular having applied thereon an anti-fouling covering in accordance with the present invention.

Referring now to the drawings, Fig. 1 shows a first example of a strip 10 of anti-fouling material, usually of copper or copper alloy such as cupro-nickel, which forms the basis of the present invention.

The strip 10 is formed with a plurality of substantially parallel, elongate slots 12 having their longitudinal axes extending across the width of the strip 10. The slots 12 are formed in a number of columns, each of which extends along the length of the strip 10, with adjacent columns being staggered relative to one another so that the ends of each slot 12 extend slightly between the vertically adjacent slots 12 of the horizontally adjacent columns. The slots 12 are preferably six-sided, with V-shaped ends as shown. It will be understood that Fig. 1 is schematic in nature for the purpose of clearly illustrating the arrangement of the slots 12. The

dimensions of the slots relative to the width of the strip, and the number of columns of slots 12, may vary from the illustrated example.

It can be seen that the slots 12 divide the material of the strip 10 into a number of horizontal portions 14 between each pair of vertically adjacent slots 12 in each column, interconnected by relatively narrower diagonal arms 16. This arrangement allows the strip 10 to deform along its longitudinal axis, so as to accommodate differential expansion or contraction between the strip 10 and the elastomer coating of a pipe or the like upon which the strip is wound, without buckling which would occur with a solid sheet of material. Such differential expansion or contraction may occur during curing of the elastomer coating or subsequently during use of the coated article.

In the example of Fig. 1, the vertical spacing between vertically adjacent slots 12 is twice the width of the slots 12 themselves. Accordingly, the slots occupy approximately one third of the total area of the strip 10. The proportion of the area occupied by the slots may be varied by varying the arrangement and/or spacing of the slots. Fig. 2 shows a second example of a strip 20 in which the width of the slots 22 is equal to their vertical spacing, so that the slots 22 occupy approximately half of the total area of the strip 20. The horizontal portions 24 and diagonal arms 26 of the strip 20 are correspondingly narrower than those of Fig. 1.

The slots 12, 22 of Figs. 1 and 2 are dimensioned and arranged such that the material can deform so as to expand and contract in at least one direction to

accommodate thermal expansion and contraction of an underlying elastomer coating to which the material is secured, in use. The dimensions and arrangement of the slots are thus determined by the differential thermal expansion and contraction characteristics of the anti-fouling material and the elastomer coating.

For the purposes of the present invention, it is preferred that the strip 10 or 20 be 0.5 mm to 2 mm in thickness and the slots 12 or 22 range in size from 3mm long by 1 mm wide to 50 mm long by 6 mm wide. The width of the strip 10 or 20 may vary as required. The size and spacing of the slots is preferably selected such that the slots occupy 25% to 50% of the strip area, providing exposure of the strip material in the range 75% to 50%. This compares advantageously with exposure typically of 37% or less with existing systems such as that discussed at (c) above. The size and spacing of the slots and the thickness of the strip also affects the flexibility of the strip and its ability to expand or contract longitudinally. Accordingly, these parameters may be varied to provide the required degree of flexibility in particular applications of the invention.

If a metal strip as shown in Figs. 1 and 2 were applied directly to a layer of uncured elastomer on a pipe or the like, then subsequent curing of the elastomer would result in elastomer extruding through the slots when it goes into a flow condition and expands during the autoclaving cycle. The elastomer would thus cover the metal wholly or partially and thereby eliminate or substantially reduce its anti-fouling properties.

This may be prevented by wrapping a sheet material on

top of the anti-fouling coating prior to final curing of a coated article, as shall be discussed further below. Alternatively, a thin layer of uncured elastomer may be applied to one side of the strip prior to the strip being applied to the article to be protected. In one method of applying the invention, the elastomer coating on the article is at least partially cured and the elastomer layer of the strip remains uncured before application of the side of the strip carrying the thin elastomer layer to the coated structure. The thinness of the layer of uncured elastomer is such that it does not extrude over the outer surface of the strip during subsequent curing. In an alternative method, the elastomer coating of the structure is uncured or partially cured and the elastomer layer of the strip is partially cured before the application of the anti-fouling material to the structure.

Fig. 3 shows a side view of a strip 10 with a thin layer of uncured elastomer 28 applied to one side thereof. Before application of the layer 28, the surface of the strip 10, and particularly the edges thereof, is cleaned and lightly abraded, suitably by blast cleaning using aluminium oxide, at low pressure to avoid distortion of the metal. A suitable primer and elastomer bonding agent is applied by roller, spray or brush, and the elastomer layer 28 is applied thereto and pressed into place by means of a roller or the like. A release sheet 30 of paper, polyethylene or the like is applied to the outer surface of the layer 28, allowing the coated strip to be rolled onto a reel or the like prior to application to the article which is to be protected. It is preferred that the layer 28 be 0.5 mm to 1 mm in thickness, less than or equal to the thickness of the metal strip 10. The composite strip

comprising the metal strip 10 and elastomer layer 28 is designated by the numeral 32.

Fig. 4 shows the preferred method of applying the strip 10 or composite strip 32 to a pipe 34. The slots 12 on the strip 10/32 are indicated, and it will be understood that these are provided over substantially the entire surface area of the strip. The pipe 34 is first coated with anti-corrosion and/or thermal insulation materials as required, by any suitable method, as is well known in the art. In this example, an elastomer coating 36, typically 6 mm to 12 mm in thickness, is shown. After the coating 36 has been at least partially cured, the strip 10/32 is wound onto the coated pipe 34, under tension, in helical fashion while the pipe 34 is rotated about its longitudinal axis.

In the case of the composite strip 32, the release sheet 30 is removed as the strip 32 is wrapped. A nylon pressure tape (not shown) is then helically wrapped under tension on top of the strip 32, as is known in the art, before autoclaving to cure the elastomer layer 28 and bond the strip 32 to the elastomer coating 36. Alternatively, as noted above, the coating 36 can remain uncured or partially cured prior to wrapping of the strip 32, and the elastomer layer 28 of the strip 32 partially cured prior to wrapping.

Because the elastomer layer 28 of the strip is no thicker than the metallic strip 10, it should not extrude any further than the outer surface of the strip 10 after final curing. The slots 12 allow the strip 10 to deform along its length with expansion and contraction of the elastomer coating 36 during the

curing process, and to accommodate differential thermal expansion and contraction between the coating 36 and the strip 10 in subsequent use of the pipe.

In the case where the strip 10 is applied without an elastomer backing layer, a strip of nylon material is wound on top of the strip 10 prior to application of the pressure tape. This nylon strip serves to prevent extrusion of elastomer through the slots 12 during final curing. It is preferably the same width as the anti-fouling strip 10, and may be wrapped simultaneously therewith. In this case the elastomer coating 36 is preferably uncured or partially cured prior to application of the strip 10.

The invention thus provides improved anti-fouling coating materials, improved coated structures employing such materials, and improved methods of applying such materials to structures.

Improvements and modifications may be incorporated without departing from the scope of the invention.

Claims

1. A metallic, anti-fouling, coating material adapted to be applied to an elastomer-coated article to be protected, said material comprising a generally planar sheet of anti-fouling material having a plurality of elongate slots formed therein.

2. A coating material as claimed in Claim 1, wherein said slots are arranged substantially parallel to one another and are arranged in columns.

3. A coating material as claimed in Claim 2, wherein adjacent columns are vertically staggered relative to one another.

4. A coating material as claimed in Claim 2 or Claim 3, wherein the slots are dimensioned and arranged such that the material can deform so as to expand and contract in at least one direction to accommodate thermal expansion and contraction of an underlying elastomer coating to which the material is secured, in use.

5. A coating material as claimed in any preceding Claim, wherein said slots have six sides, having generally V-shaped ends.

6. A coating material as claimed in Claim 5, wherein the slots are arranged in vertically staggered columns, the V-shaped ends of the slots of one column being interleaved with the V-shaped ends of the slots of adjacent columns.

7. A coating material as claimed in any preceding

Claim, wherein the material comprises an elongate strip adapted to be helically wrapped about the length of a tubular article.

8. A coating material as claimed in Claim 7, wherein the elongate slots extend across the width of the strip, allowing the strip to deform longitudinally with expansion and contraction of the underlying elastomer coating, in use.

9. A coating material as claimed in any preceding Claim, wherein the slots occupy 50% or less of the total surface area of the material.

10. A coating material as claimed in Claim 9, wherein the slots occupy at least 25% of the total surface area of the material.

11. A coating material as claimed in any preceding Claim, wherein the sheet of anti-fouling material has a thickness in the range 0.5 mm to 2 mm.

12. A coating material as claimed in any preceding Claim, wherein the sheet of anti-fouling material has a layer of elastomer material applied to one surface of said sheet.

13. A coating material as claimed in Claim 12, wherein said elastomer material has a thickness less than or equal to that of the sheet of anti-fouling material.

14. A coating material as claimed in Claim 13, wherein the thickness of said elastomer material is in the range 0.5 mm to 1 mm.

15. A coating material as claimed in any preceding Claim, wherein the length of the slots is in the range 3 mm to 50 mm.

16. A coating material as claimed in any preceding Claim, wherein the width of the slots is in the range 1 mm to 6 mm.

17. A structure having an elastomer coating applied to the surface thereof and a metallic anti-fouling coating as claimed in any preceding Claim applied to the surface of the anti-corrosion coating.

18. A structure as claimed in Claim 17, wherein said structure is a tubular structure and said anti-fouling material is in the form of an elongate strip helically wrapped about and along the tubular structure.

19. A method of forming a structure as claimed in Claim 17 or Claim 18, comprising the steps of applying an elastomer coating to said structure, applying anti-fouling material as claimed in any one of Claims 1 to 16 to said tubular member on top of said elastomer coating so as to cover substantially all of the coated surface of the structure, and processing the resulting assembly to cure said elastomer coating and/or the elastomer layer of said anti-fouling material (if present) so as to bond said anti-fouling material to said coating.

20. A method as claimed in Claim 19, wherein the elastomer coating is uncured or at least partially cured prior to application of the anti-fouling material to the structure.

21. A method as claimed in Claim 19 or Claim 20, wherein said anti-fouling material includes an elastomer layer and wherein said elastomer layer is uncured or partially cured prior to the application of the anti-fouling material to the structure.

22. A method as claimed in Claim 19 or Claim 20 or Claim 21, wherein a pressure strip is wrapped on top of the anti-fouling material prior to final curing of the assembly.

23. A method as claimed in Claim 22, wherein the anti-fouling material does not include an elastomer layer and wherein a strip of material, such as nylon, is wrapped on top of the anti-fouling coating prior to the application of said pressure strip, so as to inhibit extrusion of elastomer through the slots in the anti-fouling material.

24. A method as claimed in any one of Claims 19 to 23, wherein the structure is a tubular structure and said anti-fouling material is an elongate strip applied to the structure by helically winding said strip about and along the tubular structure.

25. A metallic, anti-fouling coating material, substantially as hereinbefore described with reference to the accompanying drawings.

26. A structure having an anti-fouling coating, substantially as hereinbefore described with reference to the accompanying drawings.

27. A method of forming a structure having an anti-fouling coating, substantially as hereinbefore

described with reference to the accompanying drawings.

The Patent Office

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Application No: GB 9605856.5 **Examiner:** Alan Habbijam
Claims searched: 1-27 **Date of search:** 23 May 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): EIH (HCE) : B7A (AAEB) : F2P (P1A27, PC12, PC26, PC27, PC29) : F4S.

Int Cl (Ed.6): B63B 59/00, 59/04 : E02B 17/00 : E02D 31/06 : F16L 58/00, 58/02, 58/04.

Other: Online:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2221428 A	(DAI-ICHI HIGH FREQUENCY CO) see plate 30 provided with elongate apertures 30a, Figs 14&15 in particular.	1
X	GB1576441	(USINES CHAUSSON) see eg Figs 2&9 and description at lines 18-28 on p4.	1,2&9 at least
X	GB686902	(USINES CHAUSSON) see Figs 1&2 and lines 120-130 on p2.	1-3&9 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.